Determination of Physico-Chemical Parameters and Water Quality Index (Wqi) of Chandlodia Lake, Ahmedabad, Gujarat, India

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Abstract

The present study was carried outto determine various physico-chemical parameters and water quality indexof the western part of Ahmedabad District to examinethe quality of water for public consumption, recreation and other purposes. This study deals with the influence of environmental factors as well as domestic activities in the water quality in the related area.

Keywords: Water quality index; Physico-chemical; Fresh water; Chandlodia lake; Ahmedabad

Introduction

Water is an essential component of the environment and it sustains life on the earth. All organisms depend on water for their survival [1]. Freshwater bodies are important wetlands located in and around human habitations as they are generally semi natural ecosystems constructed by man in landscape suitable for water stagnation [2]. The quality ofdrinking water is essential for life. Contaminants such as bacteria, viruses, heavy metals, nitratesand salt have polluted water supplies as a result of inadequate treatment and disposal of waste fromhumans, livestock, industrial discharges, domestic discharge and extensive use of limited water resources [3]. There are a number of reported cases of typhoid, diarrhoea and other water borne diseases arising from the consumption of contaminated water. Different works have been reported by many researchers on water quality assessment. Today, contaminated water kills more people than cancer, AIDS, wars, terrorism or accidents [4]. Physico-chemical properties of the water gets varied season wise and in addition, anthropogenic activities such as agriculture, urbanization, domestic sewage, etcin the catchment area resultin the deteriorationof water quality [5]. Temperature, turbidity, nutrients, hardness, alkalinity and dissolved oxygen are some of the important factors that play a vital role for the growth of living organisms in the water body. Water quality indicates the relation of all hydrological properties including physical, chemical and biological properties of the water body. Hence, water quality assessment involves analysis of physico- chemical, biological and microbiological parameters that reflects the biotic and abiotic status of ecosystem [6]. Water quality index (WQI) provides a nominal number that represent overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into detailedinformation useful for public. WQI indicatesthe water quality in terms of index number andoffers a useful presentation of overall quality of water for public or for any intended use as well as in the pollution abatement programmes and in water quality management [7]. The present study deals with the assessment of physico-chemical characteristics of water and on the basis of these variousparameters, water quality index is determined which revealed in the Chandlodia Lake, Ahmedabad, Gujarat, India.

Materials and Methods

Study area

Chandlodia lake is the man-made lake located at the Western part of the Ahmedabad city. The lake is bounded by a wooden hedge. Adjacent to the study area, there exists a temple.The waste from the temple including polythene bags and the flowers were directly added into the lake. Beside, solid wastes and contaminated water which are utilized by the local peoples are also released into the lake.

Location: Jagatpur road, Chandlodia, Ahmedabad.

Latitude: 23˚05'00.05" N

Longitude: 72˚33'09.43" E

Areacovered: 22,940 m^2

Maintained by: Ahmedabad Urban Development Authority (**AUDA**), civic body of Ahmedabad Municipal Corporation (**AMC**).

Methods

Five different sites were selected for the collection of water samples (Figures 1 and 2). The samples were collected in sterilized polythene bottles of one litter capacity. Monitoring was performed during September 2013 to August 2014 (seasonal monsoon, winter and summer). For unstable parameters such as temperature, electrical conductivity (EC), pH, and dissolved oxygen (DO) were measured at the sampling site. Samples were brought to the laboratory for analysis of other physico-chemical parameters like sodium, total alkalinity, total hardness, calcium, magnesium, chlorides, sulphate, nitrate, phosphate and biochemical oxygen demand (BOD). The parameters were compared according to the standard methods described in the literature [8-10]. The weighted arithmetic index method [11] was used for the calculation of water quality index (WQI) of the water body. Further, quality rating or sub index (q$_n$)was calculated by the following expression.

$$q_n = 100\left[V_n - V_{10}\right] \; / \; \left[S_n - V_{10}\right]$$

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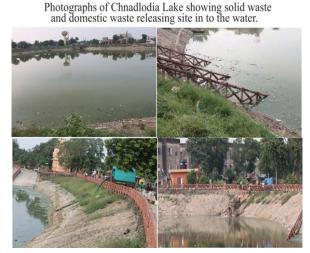**Figure 1:** Satellite image of Chandlodia Lake showing the sampling (Source : Google map)s.

Figure 2: Photographs of Chandlodia Lake showing solid waste and domestic waste releasing site in to the water.

Where: q_n=Quality rating for the nth water quality parameter,

V_n=Estimated value of the nth water quality parameters of collected sample,

S_n=Standard permissible value of the nth water quality parameter,

V_{10}=Ideal value of the nth water quality parameter in pure water.

(i.e. 0 for all other parameters except the parameter pH and Dissolved oxygen (7 and 14.6 mg/L respectively.) (Let there be n water quality parameters and quality rating or sub index (q_n) corresponding to n^{th} parameter is a number reflecting the relative of this parameter in polluted water with respect to its standard permissible value.)

Unit weight was calculated by a value inversely proportional to the recommended standard value S_n of the corresponding parameter.

$$WQI = \Sigma\ q_n W_n\ /\ \Sigma\ W_n$$

Where: W_n=Unit weight for n^{th} water quality parameter,

S_n=Standard permissible value of the nth water quality parameter,

K=Constant for proportionality.

The overall WQI was calculated by aggregating the quality rating with the unit weight linearly.

$$WQI = \Sigma\ q_n W_n\ /\ \Sigma\ W_n$$

Where:

q_n = Quality rating for the nth water quality parameter,

W_n= Unit weight for n^{th} water quality parameter.

Results and Discussion

The physico-chemical parameters such as pH, electric conductivity, alkalinity, dissolved oxygen, total dissolve solid, calcium, magnesium, chloride, biological oxygen demand, nitrate and total hardness of water were analysed for the water samples collected from the Chandlodia lake. These parameters were taken at the five points of the lake season wise (monsoon, winter and summer). All parameters with the mean value of the data with standard error were calculated as shown in the Table 1 [12,13].

Electrical conductivity

Water capability to transmit electric current is known as electrical conductivity and serves as tool to assess the purity of water [14]. This ability depends on the presence of ions, their total concentration, mobility, valence, relative concentrations and temperature of measurement [15]. The electrical conductivity ranged from 2.15 to 3.47 Ω/cm. The highest electrical conductivity was reported during winter 3.47 Ω/cm due to the addition of domestic wastage into the lake [16] and lowest in monsoon 2.15 Ω/cm because of water dilution by rainy water [17].

Total dissolved solids

Solids refersto the suspended and dissolved matter in water. They are very useful parameters describing the chemical constituents of the water and can be considered as edaphically relation that contributes to productivity within the water body [18]. The total dissolved solidsin the sampled water ranged from the 1008 to 1224 mg/L. The highest TDS reported during winter season was 1224 mg/L and lowest TDS reported during summer season was 1008 mg/L due to the addition of organic matter and solid waste into the lake [19].

pH

pH is defined as the intensity of the acidic or basic character of a solution at a given temperature. pH is the negative logarithm of hydrogen ion concentration (pH=-log [H+]). The pH in water samples range of 7.0 to 7.85 and water and stated that the pH of water is important for the biotic communities as most of the plant and animal species can survive in narrow range of pH from slightly acidic to slightly alkaline condition [18]. In study period i.e. September 2013 to August 2014 pH value ranged from 8.2 to 8.9. The maximum pH reported during summer was very low due to the water levels and concentration of nutrients in water [20] and minimum was during monsoon due to the dilution of water by addition of rain water [21].

Water Quality Index Level	Water Quality Status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

Table 1: Water Quality Index (WQI) and its status according to Chaterjee and Raziuddin [12] and Thakor et al. [13].

Alkalinity

The alkalinity of surface water is primarily a function of carbonate, hydroxide content and also includes the contributions from borates, phosphates, silicates and other bases. Alkalinity is a measure of capacity of water to neutralize a strong acid [22]. The alkalinity in the water samples ranged from 204 to 224 mg/L. The highest alkalinity recorded during winter was 224 mg/L due to high nutrients in water [4] and lowest recorded during monsoon was 204 mg/L due to dilution of water by addition into lake water [16,17].

Total hardness

The total hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions. Principally the water hardness are changed by ions such as calcium and magnesium. The total hardness from the water samples at Chandlodia Lake ranged between 310 to 348 mg/L. The highest amount of total hardness in the water was recorded during monsoon was 348 mg/L due to presence of high content of calcium and magnesium in addition to sulphate and nitrate in the sewage waste added during monsoon [23]. The lowest amount of total hardness was recorded during winter season due to low concentration of calcium and magnesium [24].

Calcium

Calcium is most abundant ions in fresh water and is important in shell construction, bone building and plant precipitation of lime. The analysis of calcium revealed a ranged between 72 to 94 mg/L. The highest amount of calcium recorded in water samples during monsoon season was 94 mg/L by the addition of sewage waste along with rain water and responsible for the increase in amount of calcium [25]. The lowest amount of calcium in water was recorded during winter season due to calcium absorbed by the large number of organisms for shell construction, bone building and plant precipitation of lime [17].

Magnesium

Magnesium is often associated with calcium in all kinds of waters, but its concentration remains generally lower than the calcium. Magnesium is essential for chlorophyll growth and acts as a limiting factor for the growth of phytoplankton [17]. The amount of magnesium recorded in the water ranged between 36 to 41 mg/L. The highest amount of magnesium in the water samples was recorded during monsoon season 41 mg/L as it is associated with calcium in all water types and during monsoon, calcium was higher in monsoon season. The lowest value was recorded during summer season due to the magnesium essentiality for chlorophyll bearing plant for photosynthesis [23].

Dissolved oxygen

The higher value of dissolved oxygen indicates good aquatic life. The amount of dissolved oxygen of Chandlodia Lake water samples ranged between 3.13 to 5.89 mg/L. The highest amount recorded during monsoon season was 5.41 mg/L due to the turbulence of water facilitating the diffusion of atmospheric oxygen and the increased solubility of oxygen at lower temperature [2]. The lowest dissolved recorded during summer season was 3.13 mg/L due to the high temperature and addition of sewage and other waste which can be responsible for low value of dissolved oxygen [17].

Chloride

The chloride in drinking water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion [17]. A chloride concentration in Chandlodia lake was noticed between 98 to 103 mg/L. The highest chloride reported in winter was 79 mg/L due to frequent run-off loaded with contaminated water from the surrounding slum area and evaporation of water [25]. The lowest value of chloride recorded during monsoon season was 98 mg/L due to the dilution of lake water by rain [26].

Nitrate

Nitrates are contributes to freshwater through discharge of sewage and industrial wastes and run off from agricultural fields [17]. The highest amount of nitrate concentration was known to support the formation of blooms [4]. The amount of nitrate recorded in the water of Chandlodia Lake ranged from 6.3 to 7.9 mg/L. The highest amount of nitrate was recorded during winter season was 7.9 mg/L because of high vegetation during winter which supported the growth of plankton [27]. The lowest amount of nitrate in water was recorded during summer season was 7.5 mg/L by the utilization by plankton and aquatic plants [25].

Biochemical oxygen demand

The biochemical oxygen demand may be defined as the oxygen required for the microorganism to performed biological decomposition of dissolved solids or organic matter in the wastewater under aerobic conditions [28]. The biochemical oxygen demand reported from water samples at Chandlodia Lake was ranged between 1.78 to 3.22 mg/L. The highest demand of oxygen in the water was recorded during monsoon season was 3.22 mg/L due to the possible addition of high amount of waste along with rain water from the surrounding and addition of organic waste in lake by certain human activities which also be responsible for the increase in BOD [29,30]. The lowest demand was recorded during monsoon season was 1.78 mg/L due to less vegetation [21]. WQI of Chandlodia Lake was established from various physico-chemical parameters in three seasons (monsoon, winter and summer) from September 2013 to August 2014. The values of various physico-chemical parameters for calculation of water quality index are presented in Table 2. Season wise WQI calculations are presented in the Tables 3-5. The WQI obtained for the water body in different seasons of study period i.e., monsoon season, winter season and summer season are 97.1624, 109.6275 and 84.1007 respectively, which indicate that water is not suitable for drinking due to high pollution level during winter season when compared to the monsoon and summer seasons.

The water is not used for public consumption due to high WQI and high pollution level. Water purification system must be installed to purify the water body as other alternatives, for domestic usage is not recommended by the civic body. The purification requires civic body initiative to clean up. This reason on a view that concerned agency had already installed three water purification systems in the city.

Conclusion

Some of the samples have total dissolved solids, pH, alkalinity, total hardness, magnesium, calcium and dissolved oxygen values exceeding the permissible limits as prescribed by Indian standards. We noticed parameters such as electrical conductivity, chloride, nitrate and biological oxygen demand values are within permissible limits. The competed WQI indicates that the water quality is poor and not totally safe for human consumption due to presence of high level of pollutants. The water is not used for public consumption and recreartion due to lack of water purification. This study showed that the water quality of Chandlodia Lake remain as it is than it will destroyed the ecosystem of the lake. The government bodu such as AUDA, AMC and other civic organisation should take the action against releasing of domestic waste directly into the lake or installed a water purification system.

Average with standard error values of physico-chemical parameters of water samples collected at Chandlodia Lake.				
Sr. No.	Parameters	Year 2013-14		
		Monsoon	Winter	Summer
1	Electrical conductivity (Ω/cm)	3.47 ± 0.18	3.14 ± 0.77	2.15 ± 0.02
2	Total Dissolve Solid (mg/L)	1224 ± 42.79	1008 ± 14.88	1142 ± 12.66
3	pH	8.6 ± 0.17	8.9 ± 0.50	8.2 ± 0.22
4	Alkalinity (mg/L)	224 ± 9.23	214 ± 3.36	204 ± 8.44
5	Total Hardness (mg/L)	348 ± 19.82	310 ± 11.2	335 ± 14.22
6	Calcium (mg/L)	94 ± 0.47	72 ± 0.12	80 ± 0.62
7	Magnesium (mg/L)	41 ± 0.39	37 ± 0.43	36 ± 0.87
8	Dissolved Oxygen (mg/L)	5.89 ± 0.36	3.29 ± 0.67	3.13 ± 0.44
9	Chloride (mg/L)	104 ± 3.4	108 ± 4.9	135 ± 4.9
10	Nitrate (mg/L)	7.2 ± 0.29	7.9 ± 0.83	6.3 ± 0.34
11	Biochemical Oxygen Demand (mg/L)	3.22 ± 0.79	2.14 ± 0.27	1.78± 0.24

Table 2: Average with standard error values of physico-chemical parameters of water samples collected at Chandlodia Lake.

Calculation of WQI of water samples in monsoon season of Chandlodia Lake							
S.No	Parameter	Observed Value (Vn)	Standard Values (Sn)	Ideal Value (V10)	Unit Weight (WN)	Quality Rating (Qn)	WnQn
1	Electrical conductivity (Ω/cm)	3.47	300	0	0.371	1.15	0.42
2	Total Dissolve Solid (mg/L)	1224	500	0	0.0037	244.8	0.90
3	pH	8.6	7.5	7	0.219	320	70.08
4	Alkalinity (mg/L)	224	120	0	0.0155	186.66	2.89
5	Tatal Hardness (mg/L)	348	300	0	0.0062	116	0.71
6	Calcium (mg/L)	94	75	0	0.025	125.33	3.13
7	Magnesium (mg/L)	41	30	0	0.061	136.66	8.33
8	Dissolved Oxygen (mg/L)	5.89	5	14.6	0.3723	90.72	33.77
9	Chloride (mg/L)	104	250	0	0.0074	41.6	0.30
10	Nitrate (mg/L)	7.2	45	0	0.0412	16	0.65
11	Biochemical Qxygen Demand (mg/L)	3.22	5	0	0.3723	64.4	23.97
					ΣW_n=1.4946	ΣQ_n=1343.3525	$\Sigma W_n Q_n$=145.2190454
WQI=97.16248187							

Table 3: Calculation of WQI of water samples in monsoon season of Chandlodia Lake.

Calculation of WQI of water samples in winter season of Chandlodia Lake							
Sr.No	Parameter	Observed Value (Vn)	Standard Valus (Sn)	Ideal Value (V10)	Unit Weight (WN)	Quality Rating (Qn)	WnQn
1	Electrical conductivity (Ω/cm)	3.14	300	0	0.371	1.04	0.38
2	Total Dissolve Solid (mg/L)	1008	500	0	0.0037	201.6	0.74
3	pH	8.9	7.5	7	0.219	380	83.22
4	Alkalinity (mg/L)	214	120	0	0.0155	178.33	2.76
5	Tatal Hardness (mg/L)	310	300	0	0.0062	103.33	0.64
6	Calcium (mg/L)	72	75	0	0.025	96	2.4
7	Magnesium (mg/L)	37	30	0	0.061	123.33	7.52
8	Dissolved Oxygen (mg/L)	3.29	5	14.6	0.3723	117.81	43.86
9	Chloride (mg/L)	108	250	0	0.0074	43.2	0.31
10	Nitrate (mg/L)	7.9	45	0	0.0412	17.55	0.72
11	Biochemical Qxygen Demand (mg/L)	2.14	5	0	0.3723	42.8	15.93
					ΣW_n=1.4946	ΣQ_n=1305.01422	$\Sigma W_n Q_n$=158.5214026
WQI = 109.627526							

Table 4: Calculation of WQI of water samples in winter season of Chandlodia Lake.

Calculation of WQI of water samples in summer season of Chandlodia Lake.						
Sr.No	Parameter	Observed Value (Vn)	Standard Valus (Sn)	Ideal Value (V10)	Unit Weight (WN)	Quality Rating (Qn)	WnQn
1	Electrical conductivity (Ω/cm)	2.15	300	0	0.371	0.71	0.26
2	Total Dissolve Solid (mg/L)	1142	500	0	0.0037	228.4	0.84
3	pH	8.2	7.5	7	0.219	240	52.56
4	Alkalinity (mg/L)	204	120	0	0.0155	170	2.635
5	Tatal Hardness (mg/L)	335	300	0	0.0062	111.66	0.69
6	Calcium (mg/L)	80	75	0	0.025	106.66	2.66
7	Magnesium (mg/L)	36	30	0	0.061	120	7.32
8	Dissolved Oxygen (mg/L)	3.13	5	14.6	0.3723	119.47	44.48
9	Chloride (mg/L)	135	250	0	0.0074	54	0.39
10	Nitrate (mg/L)	6.3	45	0	0.0412	14	0.57
11	Biochemical Qxygen Demand (mg/L)	1.78	5	0	0.3723	35.6	13.25
					ΣW_n=1.4946	ΣQ_n=1200.53	$\Sigma W_n Q_n$=125.697
WQI = 84.10076275							

Table 5: Calculation of WQI of water samples in winter season of Chandlodia Lake.

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